Discussed by Dr. Brashear, Prof. Morse, Mr. Yarnall and Prof. Hewett.

"The Effect of the American Revolution Upon the English Colonial System," by Mr. Sydney George Fisher, of Philadelphia. Discussed by Mr. Stuart Wood.

"The Hedonic Postulate," by Prof. Lindley M. Keasbey, of Bryn Mawr, Pa. Discussed by Mr. Stuart Wood, Prof. Doolittle, Mr. Richard Wood and Prof. Keasbey.

"Results of the American Ethnographical Survey," by Prof. Marion D. Learned, of Philadelphia. Discussed by Mr. Rosengarten, Mr. Richard Wood and Mr. R. P. Field.

"Regulation of Color-Signals in Marine and Naval Service," by Dr. Charles A. Oliver, of Philadelphia.

"The Ripening of Thoughts in Common," by Prof. Otis T. Mason, of Washington.

THE RÔLE OF CARBON.

BY ALBERT B. PRESCOTT.

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It may be said of any one of the chemical elements that it acts a part of its own in the formation of matter and the manifestation of energy in the world. A chemical element taken as it is, aside from questions of its genesis and its decay, stands out before exact measurement as an innate individual factor in the production of things throughout the universe. Whatever there is now being brought to light between matter and the ether or the electrons, at all events the chemical elements taken in their atomic quantities are the present facts upon which further inquiry must rest its advances.

The behavior of an element is an experimental constant, however progressive may be the theories by means of which men of science may pursue their studies. The present is for some reasons a time profitable for us to recount certain of the salient characteristics of that chemical element named at the head of this brief paper.

The registration of carbon compounds in M. M. Richter's Lexicon, amounting to 80,000 in the year 1900 and since increased by

the addition of two supplements, presents for our consideration something besides the choice of man in the direction of his chemical research. These advancing thousands of individual combinations, of determinate molecular weight and fixed elemental composition, give us evidence of the chemical productivity of carbon and of its character in relation to the other elements.

We need to keep before us the place of carbon among its relatives in the periodic system. Central as it is in its electric polarity and in the order of its valence, the leading member of a group holding an equilibrium among the other groups, its place is that of a balance of power. But an element, preëminently this element, is more than the occupant of a place, more than a mere number in a progressive system, a mere function of a weight; it is all of these perhaps, but if so it is more: it is an individual. Carbon is not wholly exceptional, however, neither in the sense of an entire lack of the variability of neighboring elements, nor in that of being the only one whose atoms can at all unite to each other in the formation of chains. It is by virtue of both its central position and its independent character that it appears, when in combination, as the element in command.

We must recognize the fact, without explanation, that the unusual ability of carbon to unite its atoms in chains is dependent upon their union with hydrogen, whose aid is thereby indispensable to the organic world. Carbon is formed for complexity only when supported by the unvarying unity of hydrogen, and by this support is provided the great capacity of carbon for extensive molecular structure.

The science of chemistry, and therefrom all physical science, has been enriched by experimental studies of molecular constitution. These are studies of determinate facts, and it is but a consistent expression of these facts that is undertaken in structural formulæ or even in the atomic theory itself, as used in the work of chemists. The several differences, for instance, between dimethyl ether and ethyl alcohol, two individuals of the composition C_2H_6O, are differences of fact. We give statement in the figurative language of the structural formula and of the atomic theory to the actual nature of the one as an ether and of the other as an alcohol. It is a discovered truth that in the alcohol one-sixth of the hydrogen is united to the oxygen more intimately than the other five-sixths of the hydrogen are united to the oxygen. It is a truth that in the ether

the union of each sixth of the hydrogen to the unit of oxygen is the same. Were chemists to abandon structural formulæ, were they to go further and desert the atomic theory, all the facts heretofore communicated would remain to be told if possible in other terms to the eye and ear.

There has been some reaction against the devotion paid to molecular constitution, and there may well be a protest against certain besetting tendencies in the teaching of this subject. Both teacher and investigator ought to be on guard against the assertiveness of the structural formula. Let us welcome as a corrective the increasing service of empirical formulæ, the appearance of the formula index once a year in the journals, the constant uses of the Lexicon of Carbon Compounds, and the adoption of empirical formulæ frequently for summation and comparison as well as for contrast. Of course I refer only to these formulæ when of determined molecular weight, and we must recognize that no small share of the vantage ground in organic chemistry since 1890 is indebted to the new methods of molecular weight determination.

It is the nature of the carbon atom that has made attractive to chemists the work they have done upon molecular structure. It was long ago established that the character of a compound depends partly upon what elements unite to make it and partly upon the order of their union. No atom in a molecule is wholly without influence upon every other however remote. And as to the effect of any element in a compound, it is a fair conclusion that the numbers of its atoms within the molecule count for something, the relative position of its atoms may count for more, the structural concentration of its atoms will count for most.

When the nature of the proteids and other matters manifesting life shall become known we may be sure that molecular constitution will be included in that knowledge. We may be sure that the carbon atom, or some theoretical equivalent of what we now term the atom, will be a very determinate part of the question. This is not to say that chemical synthesis alone can compass vitality, but rather that vitality must still depend upon the chemical constitution of the vitalized material. We cannot speak lightly of the limits of what may come to be defined as the molecule, or count confidently upon future restrictions of its extent. We may well admit, however, that the rim of the molecule wherever placed must continue to bound the province of chemical study.

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